ACTA ARACHNOL., 40: 17-21, June 25, 1991

Direct Evidence of Food Limitation for Growth Rate and Body Size in the Spider *Nephila clavata*

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宮下　直[1)]：ジョロウグモの成長速度と体サイズの餌による制約の直接証拠

Abstract: Growth process of the spider *Nephila clavata* was obtained under three different feeding conditions by rearing in field cages. Amount of food supply greatly influenced rate of growth and body size. The mean body size in three natural populations were variable, but within the range of the two extreme feeding conditions, indicating food limitation as well as flexibility of growth process in this species.

Introduction

A considerable amount of evidence has revealed that growth rate and body size of spiders are limited by feeding success in the field. Demonstration of food limitation is usually made by comparison of laboratory reared specimens in which food level was known, with those in the field (MIYASHITA, 1968; KESSLER, 1973; ANDERSON, 1974). A less common method is by field experiment; i.e., by comparing a food supplemented population with a control (WISE, 1975, 1979). Most of these study subjects were, however, concentrated on cursorial spiders or relatively small web-builders. Possible reasons are that large web-builders are difficult to rear and population density of such spiders is rather low.

The spider *Nephila clavata* is a common orb-weaving spider in Japan. Both the rate of growth and the size of adult females are considerably large among web-builders. MIYASHITA (1990) reported that inter-populational variation in size of adult females was also large, which was indirect evidence of food limitation in the field. The present paper demonstrates directly food limitation for growth and size by comparing reared and field specimens.

Materials and Methods

Experiments were performed in Tokyo University Forest Experimental Station at Tanashi. Thirty 4th or 5th instar spiders were collected from the field on July 16, 1989, and were divided

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into three groups of equal number. Each group was released into a field cage approximately 3.6m × 3.6m × 2.0m high, which was timber-framed and covered with nylon net of 1.5mm mesh.

Food supply to spiders was manipulated so that the three groups differed in food level. From July 18 to August 4, 3 to 10 fruitflies per day were supplied to each spider in the 'rich' treatment, 1 to 4 in 'intermediate', and no flies in the 'poor' treatment. Small insects that entered through the net or emerged inside the cage were sometimes observed being eaten by spiders. The mean feeding frequency ((no. of observed feeding)/(total no. observed) × 100) for these prey was 5.8 ± 2.93% (mean ± S.D., n = 10). Since sexual discrimination became gradually possible from August, I established different feeding schedules for each sex.

Female: From August 9 to September 1, one mealworm or cricket was supplied to each spider every other day in the 'rich' treatment. In the 'intermediate' treatment, fruit flies or a small cricket was supplied every other day, so that total amount of food was approximately one-third of the 'rich' treatment. In the 'poor' treatment, about 5 fruitflies were added once every four days.

Males: From August 9 to September 20, approximately 10 fruitflies were supplied every other day in the 'rich' treatment, 5 in the 'intermediate', and 1 to 2 once every four days in the 'poor' treatment. No food was supplied to adult males and sub-adult males which were close to the final molt.

Body length of all spiders was measured on July 18 & 27 and August 4. Body length was also measured on September 1, and on the day of final molt for females and males, respectively.

Field observations were conducted in three study sites in Tokyo University Forest Experimental Station at Tanashi in 1989. Site A was a young pine plantation of which height was ca. 3m. The undergrowth was rich in grasses and herbs. Site B was located at the forest edge near a research building. Site C was a garden: upper vegetation was sparse and undergrowth was very poor.

Body length of spiders was measured once a week to once every three weeks. In 1990, several sub-adult males at site A were marked individually with paint. The date of final molt and body length were recorded.

Results

Figure 1 shows change in the mean body length of spiders under three different feeding conditions. Since sexual discrimination was impossible for most individuals until August 4, all individuals were included during that period, whereas values on September 1 were only for females. At the start of the experiment, there was no significant difference in body length among the treatments. However, significant difference were observed from July 27 onward (One-way ANOVA, $p < 0.02$). Thus, growth rate and size appeared to be strongly influenced by feeding conditions. Figure 1 also shows mean body length of females in natural populations. Although body length varied considerably among populations, all of them were within the range of the experimental treatments. This means that, by manipulating food levels, variation of body size

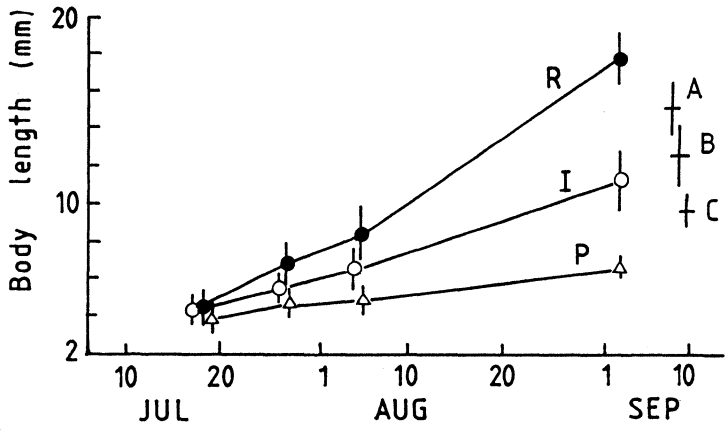

Fig. 1 Change in the mean body length of *N. clavata* under three different feeding conditions and the mean body length of natural populations (A, B, C) on September 7.
R; 'Rich' treatment, I; 'Intermediate' treatment, P; 'Poor' treatment.
Vertical bars are 95% confidence limit. Sample size is 10 until August 4 in all treatments, 4, 5, 4 on September 1 in R, I, P, respectively, 19, 13, 8 in A, B, C, respectively.

larger than that in field populations can be created.

Figure 2 shows the relationship between date of final molt of males and their body length. Figure 2A shows the results for reared individuals. Although number of samples was small, there was no overlap in the range of body length among treatments. The dates of final molt in the 'poor' treatment were delayed by nearly one month compared to those in others. However, the difference between 'rich' and 'intermediate' treatments was insignificant. The reason is not clear but the feeding condition in 'intermediate' may be relatively rich as I had expected. The body length of males in the field populations also showed a decreasing trend with time. Comparison of field and reared results revealed that size and timing of maturation of males were limited by feeding conditions in the field.

Discussion

The present experiment demonstrated that potential size variation in *N. clavata* was considerably larger than variation observed in field populations. This may be further generalized by the following: Of 12 populations (including those in the same habitat in different years) studied by the author so far, the mean body length in early September at Site A was the second largest (the largest being only slightly larger) and that in site C was the smallest. These results suggest the flexibility of the growth process, which may enable this species to survive in various environmental conditions. What then, makes it possible to produce such large variation? One reason may be that spiders are tolerant to starvation for a long period of time (NAKAMURA,

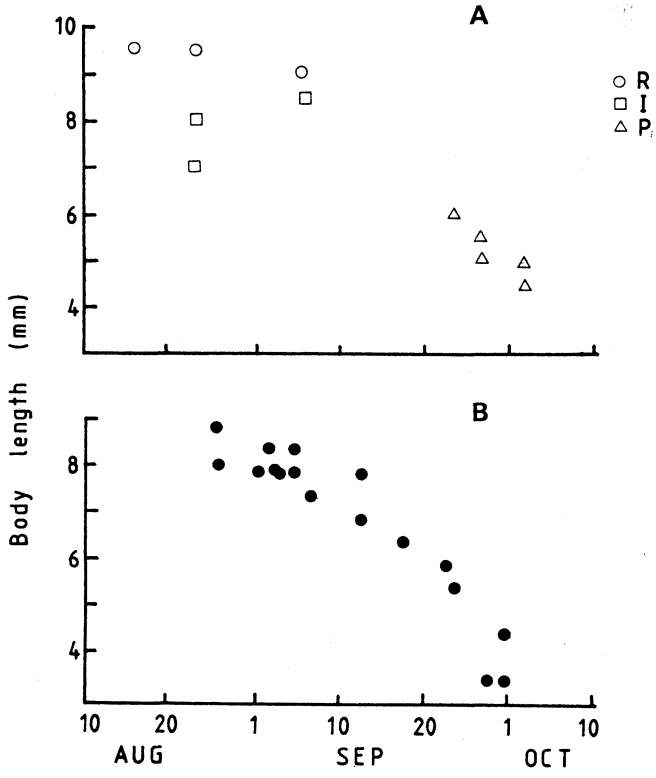

Fig. 2 Relationship between date of final molt of males and their body length after the molt under experimental (A) and natural conditions (B). R, I and P are the same as in Fig. 1.

1972; TANAKA and ITO, 1982). Another reason may be that this species can realize a high potential growth rate under conditions of rich food availability. The mean body weight increased by nearly 300 times within only 4 months in one population (MIYASHITA, 1986). However, comparative data in other species are rather scanty at present.

This paper may also explain the following statement by YAGINUMA (1986) in regard to this species that "Males that emerged in late summer are large and those that emerged in autumn are small". The influence of male size and timing of maturation on male fitness, which is not clear yet, will be presented elsewhere.

Acknowledgments

I am indebted to Prof. K. KATAGIRI, Dr. K. FURUTA for encouragements and to Mr. S. LAWSON for correction of English expressions. Mr. K. YAGI, the chief of University Forest Experimental Station at Tanashi, generously permitted the use of the research site.

摘　　要

ジョロウグモを野外網室内で3つの異なる条件下で飼育し，成長経過を調べた．餌供給量の違いは，成長速度やサイズに強い影響を与えた．野外における3つの個体群の平均サイズの変異は大きかったが，いずれも飼育下におけるサイズの範囲内にあった．これらの結果は，野外個体群における餌資源の制約とともに，成長過程の可塑性を示すものである．

References

ANDERSON, J.F., 1974. Responses to starvation in the spiders *Lycosa lenta* HENTZ and *Filistata hibernalis* (HENTZ). *Ecology,* 55: 576–585.

KESSLER, A., 1973. A comparative study of the production of eggs in eight *Pardosa* species in the field (Araneida, Lycosidae). *Tijdschr. Entomol.,* 116: 23–41.

MIYASHITA, K., 1968. Growth and development of *Lycosa T-insignita* BOES. et. STR. (Araneae:Lycosidae) under different feeding conditions. *Appl. Entomol. Zool.,* 3: 81–88.

MIYASHITA, T., 1986. Growth, egg production, and population density of the spider, *Nephila clavata* in relation to food conditions in the field. *Res. Popul. Ecol.,* 28: 135–149.

————1990. Decreased reproductive rate of the spider, *Nephila clavata,* inhabiting small woodlands in urban areas. *Ecol. Res.,* 5: 341–351.

NAKAMURA, K., 1972. The ingestion in wolf spiders II. The expression of hunger and amount of ingestion in relation to spider's hunger. *Res. Popul. Ecol.,* 14: 82–96.

TANAKA, K. and Y. ITO, 1982. Decrease in respiratory rate in a wolf spider, *Pardosa astrigera* (L. KOCH), under starvation. *Res. Popul. Ecol.,* 24: 360–374.

WISE, D.H., 1975. Food limitation of the spider *Linyphia marginata*: experimental field studies. *Ecology,* 56: 637–646.

————1979. Effects of an experimental increase in prey abundance upon the reproductive rates of two orb-weaving spider species (Araneae: Araneidae). *Oecologia,* 41: 289-300.

YAGINUMA, T., 1986. Spiders of Japan in Color. (new edition). 305pp. Hoikusha, Osaka. (In Japanese).